NASA SBIR/STTR Technologies

Software for Automated Generation of Reduced Thermal Models for Spacecraft Thermal Control

NASA Topic: S3.02 Thermal Control Systems, PI: Yi Wang, Ph.D.

Identification and Significance of Innovation

- Thermal models and analysis are extensively used in design and thermal control of NASA spacecrafts and instruments
- Conventional approaches based on general thermal mathematical models with full discretization or simple lumped-parameter models are either computationally prohibitive (days-weeks) or inaccurate, leading to prolonged design cycle and imprecise thermal control
- There is a critical need to develop efficient reduction algorithms and thermal models for tight, real-time temperature control and for analysis and design of spacecrafts and instruments at reduced time and cost
- Proposed solution leverages technological advancements in model order reduction techniques, computational analysis, and software development

Technical Objectives

Develop reliable software for automated generation of reduced thermal models for NASA spacecrafts and instruments

- Markedly reduced orders/states enable order-of-magnitude reduction in computational time (amenable for rapid design and tight thermal control)
- Mathematically rigorous (first-principle-based, without isothermal assumptions) for distributed, multidisciplinary analysis
- Well-suited for spacecrafts and instruments with complex geometries and variable orbital environments

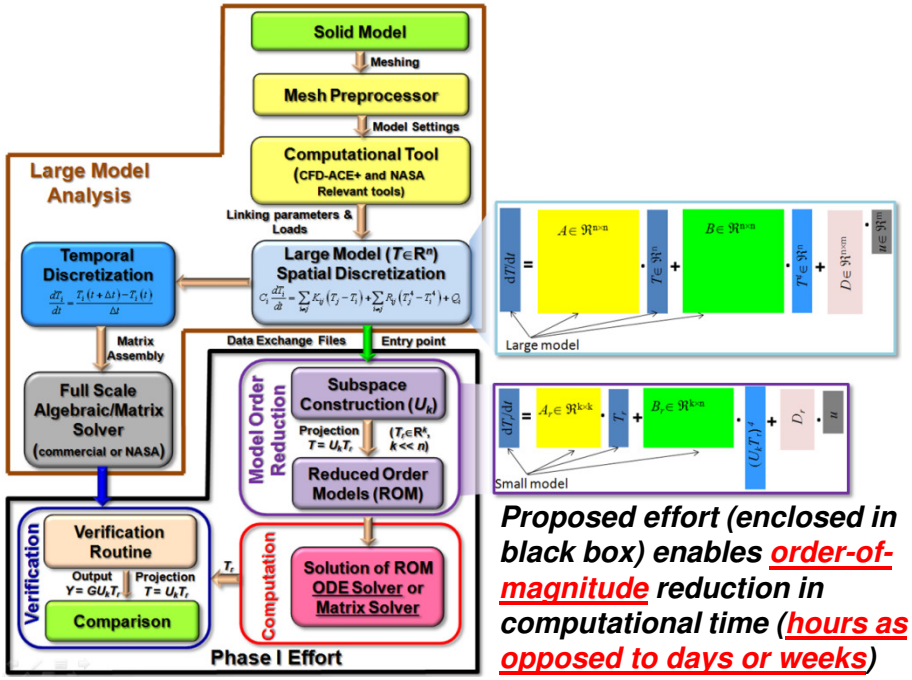
Work Plan

Phase I

- Selection of appropriate model order reduction (MOR) techniques
- Formulation and development of MOR and solver engine
- Development of easy-to-use, integrated software environment
- Development of routines for model verification
- Case studies (software verification and demonstration)

Phase II

- Improvement of MOR engine in execution efficiency and accuracy
- Expansion of interfaces with other NASA-relevant tools
- Extensive software demonstration via thermal analysis of spacecrafts or instruments with complex geometries in time-varying orbital environments



Proposed effort (enclosed in black box) enables order-of-magnitude reduction in computational time (hours as opposed to days or weeks)

NASA Applications

- Enable rapid and computationally affordable thermal analysis for better understanding of design spaces
- Develop advanced, reliable thermal control strategies for spacecrafts and instruments
- Properly arrange test procedures for rational use of instruments and facilities

Non-NASA Applications

- Broad industrial applications, including electronics cooling, rapid thermal processing, and other thermal management applications

Firm Contacts

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